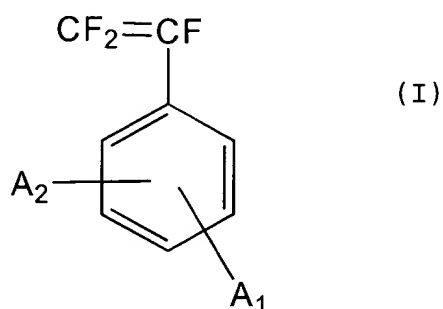
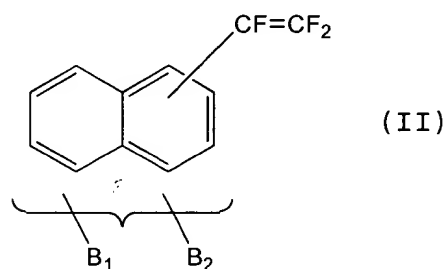


What is claimed is:

1. A membrane comprising a polymeric base film to which has been graft polymerized a monomer selected from the group consisting of monomers of formula (I)



15 and formula (II)



25 where  $A_1$ ,  $A_2$ , and  $B_1$ ,  $B_2$  are independently selected from the group consisting of:

hydrogen, lower alkyl, lower fluoroalkyl, cyclic alkyl, cyclic amine, cyclic ether, cyclic thioether,

aryl, provided that where one of  $A_1$  and  $A_2$  is hydrogen, aaryl is other than Ph, wherein Ph is phenyl,

5 CH(X)Ph, where X is selected from the group consisting of hydrogen, fluorine, lower alkyl, lower fluoroalkyl and Ph,

10 PRR' and P(OR)(OR'), where R and R' are independently selected from the group consisting of lower alkyl, cyclic alkyl and Ph, and where R and R' can be the same or different, and

15 wherein  $A_1$ ,  $A_2$ ,  $B_1$ , and  $B_2$  can be the same or different, provided that in each monomer, at least one of the substituents  $A_1$ ,  $A_2$ ,  $B_1$ ,  $B_2$  is other than hydrogen.

2. A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (I),  
20 wherein  $A_1$  is other than hydrogen, and  $A_2$  is hydrogen.

3. A membrane according to claim 1 comprising a polymeric base film to which has  
25 been graft polymerized a monomer of formula (I), wherein  $A_1$  and  $A_2$  are other than hydrogen.

4. A membrane according to claim 1 comprising a polymeric base film to which has

been graft polymerized a monomer of formula (II) wherein  $B_1$  is other than hydrogen, and  $B_2$  is hydrogen.

5           5.    A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (II), wherein  $B_1$  and  $B_2$  are other than hydrogen.

10           6.    A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (I) wherein  $A_1$  is selected from the group consisting of lower alkyl and cyclic alkyl, and  $A_2$  is the  
15    same as  $A_1$  or hydrogen.

            7.    A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (II)  
20    wherein  $B_1$  is selected from the group consisting of lower alkyl and cyclic alkyl, and  $B_2$  is the same as  $B_1$  or hydrogen.

            8.    A membrane according to claim 1  
25    comprising a polymeric base film to which has been graft polymerized a monomer of formula (I) wherein  $A_1$  is selected from the group consisting of cyclic amine, cyclic ether, cyclic thioether, and wherein  $A_2$  is hydrogen.

30

9. A membrane according to claim 1  
comprising a polymeric base film to which has  
been graft polymerized a monomer of formula (I)  
wherein A<sub>1</sub> is selected from the group consisting  
5 of aryl groups, and wherein A<sub>2</sub> is hydrogen.

10. A membrane according to claim 9,  
wherein said aryl group is a fused polycyclic  
aromatic with two fused rings.

11. A membrane according to claim 9,  
wherein said aryl group is biphenyl.

12. A membrane according to claim 9,  
15 wherein said aryl group is a heteroaromatic  
group.

13. A membrane according to claim 12,  
wherein said aryl group is a heteroaromatic group  
20 containing at least one heteroatom, wherein said  
at least one heteroatom is selected from the  
group consisting of nitrogen, oxygen and sulfur.

14. A membrane according to claim 13,  
25 wherein said heteroaromatic group contains at  
least two of said heteroatoms, and said  
heteroatoms can be the same or different.

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15. A membrane according to claim 13,  
wherein at least one of said heteroatoms is  
nitrogen which is N-alkylated or N-benzylated.

5        16. A membrane according to claim 13,  
wherein said heteroaromatic group is monocyclic.

10        17. A membrane according to claim 1  
comprising a polymeric base film to which has  
been graft polymerized a monomer of formula (I)  
wherein  $A_1$  is selected from the group consisting  
of  $PRR'$  and  $P(OR)(OR')$ , where R and R' are  
independently selected from the group consisting  
of lower alkyl, cyclic alkyl and Ph, and where R  
15 and R' can be the same or different, and wherein  
 $A_2$  is hydrogen.

20        18. A membrane according to claim 1  
comprising a polymeric base film to which has  
been graft polymerized a monomer of formula (I)  
wherein  $A_1$  is selected from the group consisting  
of Me and  $CH(X)Ph$ , where X is selected from the  
group consisting of hydrogen, fluorine, Me, and  
Ph, and  $A_2$  is the same as  $A_1$  or hydrogen.

25

19. A membrane according to claim 1  
comprising a polymeric base film to which has  
been graft polymerized a monomer of formula (II)  
wherein  $B_1$  is selected from the group consisting

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of Me and CH(X)Ph, where X is selected from the group consisting of hydrogen, fluorine, Me and Ph, and B<sub>2</sub> is hydrogen.

5           20. A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (I) wherein A<sub>1</sub> is Me and A<sub>2</sub> is Me or hydrogen.

10           21. A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (II) wherein B<sub>1</sub> is Me and B<sub>2</sub> is Me or hydrogen.

15           22. A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (I) wherein A<sub>1</sub> is para-Me, A<sub>2</sub> is hydrogen, and said base film comprises poly(ethylene-co-  
20 tetrafluoroethylene).

23. A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized a monomer of formula (II)  
25 wherein B<sub>1</sub> is Me, B<sub>2</sub> is hydrogen, and said base film comprises poly(ethylene-co-tetrafluoroethylene).

24. A membrane according to claim 1  
30 comprising a polymeric base film to which has

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been graft polymerized one monomer selected from the group consisting of said monomers of formula (I) and formula (II), whereby the grafted chains are homopolymeric.

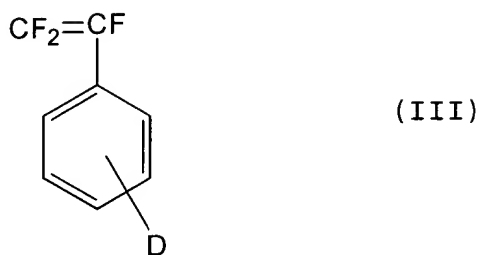
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25. A membrane according to claim 1 comprising a polymeric base film to which has been graft polymerized more than one monomer selected from the group consisting of said  
10 monomers of formula (I) and formula (II), whereby said grafted chains are copolymeric.

26. A membrane according to claim 1 comprising a polymeric base film to which has  
15 been graft polymerized more than one monomer of formula (I), whereby the grafted chains are copolymeric.

27. A membrane according to claim 1  
20 comprising a polymeric base film to which has been graft polymerized more than one monomer of formula (II), whereby the grafted chains are copolymeric.

28. A membrane according to claim 1  
25 comprising a polymeric base film to which has been graft polymerized a monomer of formula (III) in addition to said monomers selected from the group consisting of monomers of formula (I) and  
30 formula (II):



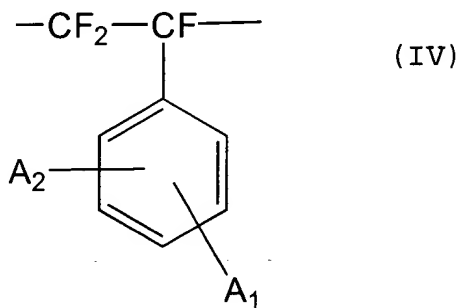
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where D is selected from the group consisting of hydrogen, fluorine,  $\text{CF}_3$ ,  $\text{CF}_2\text{H}$ ,  $\text{CF}=\text{CF}_2$ ,  $\text{SO}_2\text{F}$  and  $\text{SO}_3^-\text{M}^+$  where  $\text{M}^+$  is a suitable counterion.

10

29. A membrane comprising a polymeric base film with grafted chains comprising monomer units selected from the group consisting of monomer units of formula (IV)

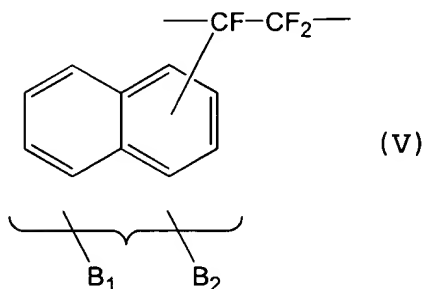
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20

and formula (V)

25



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where  $A_1$ ,  $A_2$ , and  $B_1$ ,  $B_2$  are independently  
5 selected from the group consisting of:

hydrogen, lower alkyl, lower  
fluoroalkyl, cyclic alkyl,  
cyclic amine, cyclic ether, cyclic  
thioether,

10 aryl provided that where one of  $A_1$  and  
 $A_2$  is hydrogen, aryl is other than Ph,

CH(X)Ph, where X is selected from the  
group consisting of hydrogen, fluorine,  
lower alkyl, lower fluoroalkyl and Ph,  
15 wherein Ph is phenyl,

PRR' and P(OR)(OR') where R and R' are  
independently selected from the group  
consisting of lower alkyl, cyclic alkyl and  
Ph, and where R and R' can be the same or  
20 different,

and wherein  $A_1$ ,  $A_2$ ,  $B_1$ , and  $B_2$  can be the same  
or different, provided that in each of said  
monomer units at least one of the substituents  $A_1$ ,  
 $A_2$ ,  $B_1$ ,  $B_2$  is other than hydrogen.

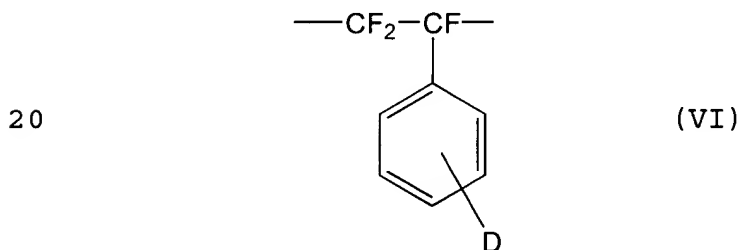
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30. A membrane according to any one of  
claims 1, 20-23, 28 or 29 wherein at least a  
portion of the grafted chains are crosslinked.

31. A membrane according to claim 29 wherein at least a portion of said monomer units further comprise at least one ion-exchange substituent, whereby said membrane is an ion-exchange membrane.

32. An ion-exchange membrane according to claim 31 wherein said at least one ion-exchange substituent is a sulfonate or sulfonic acid substituent.

33. An ion-exchange membrane according to claim 31 comprising a polymeric base film with grafted chains further comprising monomer units of formula (VI) in addition to said monomer units selected from the group consisting of monomer units of formula (IV) and formula (V):



where D is selected from the group consisting of hydrogen, fluorine,  $\text{CF}_3$ ,  $\text{CF}_2\text{H}$ ,  $\text{CF}=\text{CF}_2$ ,  $\text{SO}_2\text{F}$  and  $\text{SO}_3^-\text{M}^+$  wherein  $\text{M}^+$  is a suitable counterion.

34. An ion-exchange membrane according to claim 31 wherein at least a portion of said

monomer units comprise at least two ion-exchange substituents.

35. An ion-exchange membrane according to  
5 claim 31 wherein at least 50% of said monomer units in said grafted chains have at least one ion-exchange substituent per monomer unit.

36. An ion-exchange membrane according to  
10 claim 31 wherein said grafted chains comprise at least two different types of ion-exchange groups.

37. An ion-exchange membrane according to  
15 claim 31 wherein said grafted chains comprise an anion-exchange group and a cation-exchange group.

38. An ion-exchange membrane according to  
any one of claims 31 or 33 wherein at least a portion of the grafted chains are crosslinked.  
20

39. An ion-exchange membrane according to  
claim 31 wherein said ion-exchange membrane is substantially gas impermeable.

40. An ion-exchange membrane according to  
25 claim 32 wherein said ion-exchange membrane is substantially gas impermeable.

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41. An ion-exchange membrane according to claim 31 wherein said monomer units are of formula (IV).

5 42. An ion-exchange membrane according to claim 41 wherein  $A_1$  is selected from the group consisting of Me and  $CH(X)Ph$ , where X is selected from the group consisting of hydrogen, fluorine, Me and Ph, and  $A_2$  is the same as  $A_1$  or hydrogen

10

43. An ion-exchange membrane according to claim 41 wherein  $A_1$  is Me and  $A_2$  is Me or hydrogen.

15

44. An ion-exchange membrane according to claim 41 wherein  $A_1$  is para-Me,  $A_2$  is hydrogen, said base film comprises poly(ethylene-co-tetrafluoroethylene), and said at least one ion-exchange substituent is a sulfonate or sulfonic acid group.

20

45. An ion-exchange membrane according to claim 31 wherein said monomer units are of formula (V).

25

46. An ion-exchange membrane according to claim 45 wherein  $B_1$  is selected from the group consisting of Me and  $CH(X)Ph$ , where X is selected from the group consisting of hydrogen, fluorine, Me and Ph, and  $B_2$  is hydrogen.

30

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47. An ion-exchange membrane according to claim 45 wherein B<sub>1</sub> is Me and B<sub>2</sub> is Me or hydrogen.

5

48. An ion-exchange membrane according to claim 45 wherein B<sub>1</sub> is Me, B<sub>2</sub> is hydrogen, said base film comprises poly(ethylene-co-tetrafluoroethylene), and said at least one ion-exchange substituent is a sulfonate or sulfonic acid group.

10

49. An electrode apparatus comprising an ion-exchange membrane of claim 39.

15

50. An electrode apparatus comprising an ion-exchange membrane of claim 40.

51. A membrane electrode assembly comprising an ion-exchange membrane of claim 39.

20

52. A membrane electrode assembly comprising an ion-exchange membrane of claim 40.

53. An electrochemical fuel cell comprising an ion-exchange membrane of claim 39.

25

54. An electrochemical fuel cell comprising an ion-exchange membrane of claim 40.

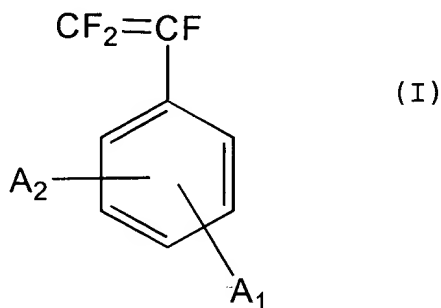
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55. An electrochemical fuel cell according to any one of claims 53 or 54 wherein said polymeric base film is less than 100  $\mu\text{m}$  thick.

5 56. A membrane prepared by subjecting a membrane of claim 1 to a reaction process selected from the group consisting of halomethylation, sulfonation, phosphonation, amination, carboxylation, hydroxylation and  
10 nitration.

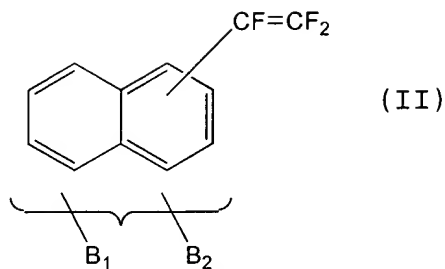
57. A method of preparing a membrane, said method comprising graft polymerizing to a polymeric base film a monomer selected from the  
15 group consisting of monomers of formula (I)



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and formula (II)

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wherein in the selected monomer at  
 10 least one of  $A_1$ ,  $A_2$ , and at least one of  $B_1$ ,  $B_2$  is  
 a substituent other than hydrogen which activates  
 said monomer with respect to said graft  
 polymerizing, and said method further comprises:

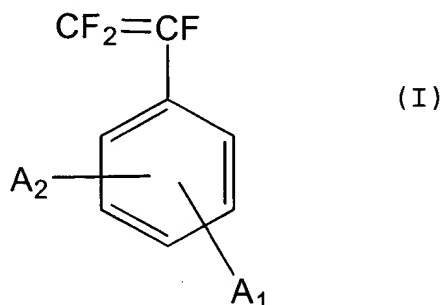
introducing a sulfonate group into at least  
 15 a portion of said graft polymerized monomer  
 units; and

converting at least a portion of said  
 substituent to substituent which are deactivating  
 with respect to desulfonation.

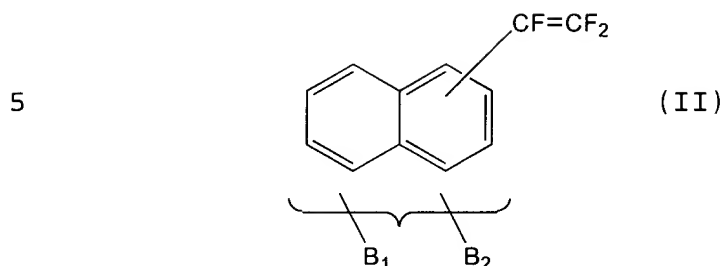
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58. A method of preparing a membrane, said  
 method comprising graft polymerizing to a  
 polymeric base film a monomer selected from the  
 25 group consisting of monomers of formula (I)

30



and formula (II)



10 where  $A_1$ ,  $A_2$ , and  $B_1$ ,  $B_2$  are independently selected from the group consisting of:

hydrogen, lower alkyl, lower fluoroalkyl, cyclic alkyl, cyclic amine, cyclic ether, cyclic thioether,

15 aryl, provided that where one of  $A_1$  and  $A_2$  is hydrogen, aryl is other than Ph, wherein Ph is phenyl,

CH(X)Ph, where X is selected from the group consisting of hydrogen, fluorine, lower alkyl,  
20 lower fluoroalkyl and Ph,

PRR' and P(OR)(OR') (where R and R' are independently selected from the group consisting of lower alkyl, cyclic alkyl and Ph, and where R and R' can be the same or different, and

25 wherein  $A_1$ ,  $A_2$ ,  $B_1$ , and  $B_2$  can be the same or different, provided that in each monomer at least one of the substituents  $A_1$ ,  $A_2$ ,  $B_1$ ,  $B_2$  is other than hydrogen.



an aryl group selected from the group  
5 consisting of monocyclic heteroaromatics, fused  
polycyclic heteroaromatics, and heteroaromatic  
ring assemblies having at least one nitrogen  
atom,

A<sub>2</sub> and B<sub>2</sub> are hydrogen,  
the method further comprising alkylating or  
benzylating at least a portion of any of said  
nitrogen atoms of said aryl group, the nitrogen  
20 atoms of said cyclic amine, or the phosphorus  
atoms of said phosphine or phosphite.

phosphines of the formula  $\text{PRR}'$  and phosphites of formula  $\text{P(OR)(OR')}$  where R and R' are independently selected from the group consisting

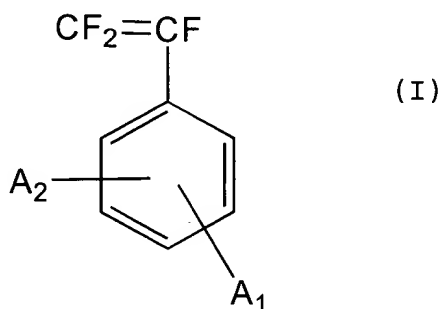
of lower alkyl, cyclic alkyl and Ph, and where R and R' can be the same or different, and

A<sub>2</sub> and B<sub>2</sub> are hydrogen,

the method comprising the sequential steps  
5 of introducing a nitro group into at least a portion of the grafted monomer units of said membrane and converting at least a portion of said nitro groups to quaternary ammonium groups,

the method optionally further comprising  
10 converting said phosphine or phosphite to an ion-exchange substituent.

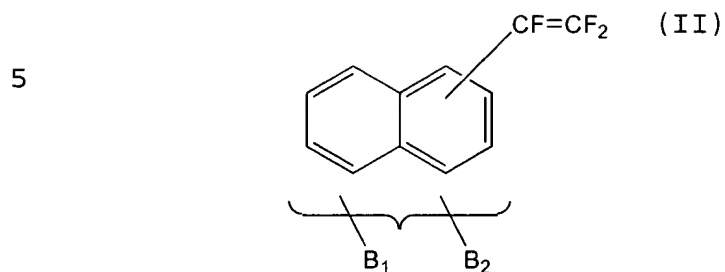
61. A method of preparing a membrane  
comprising graft polymerizing to a polymeric base  
15 film a monomer selected from the group consisting of monomers of formula (I)



20

25

and formula (II)



10

where A<sub>1</sub> and B<sub>1</sub> are independently selected from the group consisting of

PRR', P(OR)(OR'), and SR where R and R' are independently selected from the group consisting of lower alkyl, cyclic alkyl and Ph, and where R and R' can be the same or different, and

A<sub>2</sub> and B<sub>2</sub> are the same as A<sub>1</sub> and B<sub>1</sub> respectively or hydrogen,

20 the method further comprising oxidizing at least a portion of the PRR', P(OR)(OR'), or SR groups.

62. The method of claim 61 further comprising introducing ion-exchange substituents into at least a portion of said monomer units.

63. The method of claim 61, wherein A<sub>1</sub> and B<sub>1</sub> are independently selected from the group SR,

where R is selected from the group consisting of lower alkyl, cyclic alkyl and Ph, wherein Ph is phenyl, and A<sub>2</sub> and B<sub>2</sub> are the same as A<sub>1</sub> and B<sub>1</sub> respectively or hydrogen, and wherein the method  
5 comprises converting at least a portion of the SR groups to sulfonate or sulfonic acid groups.

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